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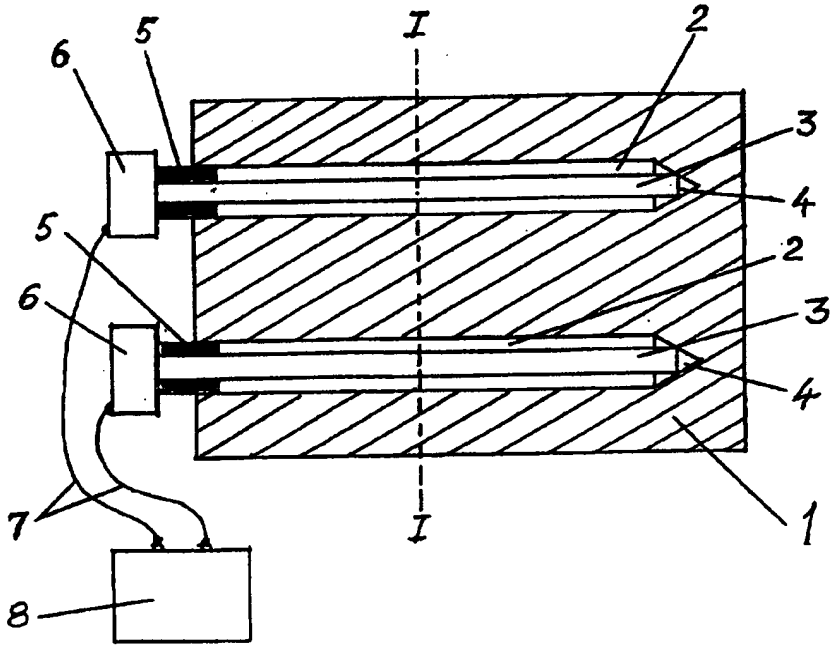

(57) Abstract

The present invention relates to an electric heating element comprising one or more electric resistance elements (3) arranged in one or more closed cavities (2) in a block (1) consisting of high temperature resistant, heat conducting material. The heating element includes means for the supply of electric current (6, 7, 8) to the one or more electric resistance elements (3).

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Title of invention:

Electric heating element

Field of invention:

The present invention relates to an electric heating element for use in high temperature processes, particularly metallurgical processes.

Background art:

In a number of metallurgical processes there is a need to supply energy at high temperature levels. These include the melting of metals and alloys, the heat treatment of materials, the smelting of oxide raw material, and also to cover the energy need for processes and to compensate for energy losses in connection with transport and treatment of metallurgical products and semi-finished products. Usually the temperature levels are higher than 1000°C.

The supply of electric energy for such purposes is usually by the use of electric arcs, by induction heating, by direct heat radiation from electric heating elements or by resistance heating by conducting electric current through the materials.

The use of these methods very often needs relatively high investments and very often gives rise to maintenance problems and material problems. Further, the methods have limitations related to geometrical design and to power levels. Heating by using conventional electric resistance elements is difficult to implement in metallurgical reactors and such conventional heating elements are normally designed for lower temperatures than the temperatures that are used in metallurgical processes.

The object of the present invention is to provide an electrical heating element that is particularly suited to provide energy at high temperatures and which is especially suited for use in metallurgical processes.

Accordingly, the present invention provides an electric heating element comprising one or more electric resistance elements arranged in one or more closed cavities in a block consisting of a high temperature stable, heat conducting material, the heating element having means for supply of electric current to the one or more heating elements.

According to a preferred embodiment of the present invention, the electric resistance elements are in the form of solid bars, but electric resistance elements having other geometrical designs, such as tubeformed or coilformed elements can also be used.

The electric resistance elements are preferably made from graphite, but other high temperature stable, electrical resistance materials can also be used, such as for example materials based on carbon, silicon carbide, zirconia or molybdenum disulfide.

The block of temperature resistant, heat conducting material is preferably made from graphite, but other temperature resistant, heat conducting materials such as materials based on carbon, zirconia, and silicon carbide can also be used.

Preferably, the cavity or cavities in the block containing the electric resistance elements are either sealed against the atmosphere, in order to create a stationary atmosphere in the cavities, or means are provided for the supply of inert gas to the cavities. In both instances chemical attack such as oxidation of the electric resistance elements is avoided. In the supply of inert gas, only very minute gas volumes are used as the volumes of the cavities are small.

According to a preferred embodiment for use of the electric heating element in connection with tapping holes or tapping nozzles in metallurgical containers for molten metal, the block of temperature resistant material has an opening extending through the block, which opening can wholly or partly serve as a tapping hole or tapping nozzle.

During use, the electric resistance elements will deliver heat energy to the block of temperature resistant, heat conducting material by way of heat radiation and the surface of the block will transfer the heat energy to the actual process.

The electric heating element according to the present invention is simple and less costly than conventional heating means. The electric heating element allows increased geometrical freedom when adjusting the electric heating element to different processes and to different metallurgical reactors as the block that conducts heat to the surroundings can be adjusted to both high and low temperatures and high and low power levels. Further, the geometrical design of the block of heat resistant material can easily be adjusted to fit into any metallurgical reactor in order to supply high temperature energy to the reactors. The block that conducts heat to the metallurgical processes will have a uniform surface temperature and the temperature level in the reactors can thereby easily be maintained and controlled without overheating.

When used in metallurgical reactors, the electric heating element according to the present invention can be protected against corrosion and oxidation by providing a layer of a refractory material on the surfaces of the block. The electric heating element according to the present invention will normally constitute an integral part of the apparatus or reactor that is to be heated and the design of the block of the electric heating element will be adjusted according to the actual reactor in which it is to be used. Alternatively, the electric heating element according to the present invention can be used for heating molten metals in metallurgical reactors by partly or wholly immersing the element into the molten metal. The electric heating element can also with advantages be used for drying and for burning of refractory linings in metallurgical reactors and for the preheating of ladles and the like. In these instances the design of the block of temperature resistant, heat conducting material is adjusted to the inner form of the metallurgical reactors or ladles, in such a way that the electric heating element can be inserted into the reactors

or to preheat them. The electric heating element can be removed when the heating is finished.

Examples for the use of the electric heating element according to the present invention within the field of metallurgical processes comprises the inclusion of one or more electric heating elements in launders, ladles, tundishes used for cooling, holding furnaces, refining equipment, equipment for granulating, equipment for atomizing, tapping holes and tapping nozzles in metallurgical vessels, laboratory furnaces and in processing apparatuses generally.

Brief description of the drawings:

The invention may be carried into practice in various ways and some embodiments will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal section through an electric heating element according to the present inventing and comprising two resistance bars,

Figure 2 is a section along line I - I in Figure 1,

Figure 3 is a longitudinal section through a heating element according to the present invention equipped with one resistance bar extending through the element, and

Figure 4 shows in section a vessel for molten metal incorporating two electric heating elements according to the present invention.

Detailed description of the invention:

As shown in Figures 1 and 2, the electric heating element comprises a block 1 made from a heat resistant, heat conducting material such as graphite. The block 1 has two cylinder-shaped inner cavities 2 that run from one of the short sides of the block 1 and inwardly in the block 1. Electric resistance bars 3, preferably made from graphite, are inserted in the cavities 2 in such a way

that the inner ends 4 of the resistance bars 3 are electrically connected with the bottom of the cavities 2 and thus form a serial connection through the material in the block 1. The resistance bars 3 have a smaller diameter than the diameter of the cavities 2, thus forming an annulus between the resistance bars and the walls of the cavities 2. At the outlet end of the cavities 2 in the block 1, the resistance bars 3 are centrally arranged in the cavities by means of a gas tight electric insulating seal member 5. At the outer ends of the resistance bars 3, connector means 6 electrically connect the bars 3 via electrical cables 7 to an electric power source 8 for the supply of electric current to the resistance bars 3. The electric power source 8 can either be an alternating current source or a direct current source.

When electric current is supplied to the resistance bars 3, the bars 3 will be heated and will transfer heat by radiation through the annuli 2 to the block 1. The block 1 and its outer surface will thereby be heated and deliver heat energy to the process.

According to the embodiment of the present invention shown in Figure 3, the block 1 has one cavity 2 and 1 resistance bar 3. In this embodiment the cavity extends throughout the block 1. Gas tight electric insulating sealing means 5 are arranged in each end of the cavity 2 in order to support the resistance bar 3 in the center of the cavity 2 and in order to seal the cavity 2 against the surroundings. A hose or pipe 9 supplies inert gas to the cavity 2. The pipe 9 is connected via a valve 10 to a source 11 of inert gas. Connector means 6 are arranged at each end of the bar for the electrical connection of the bar 3 via electric cables 7 to the power source 8. By supply of electric current the electric heating element will supply heat energy in the same way as the heating element shown in Figures 1 and 2.

In Figure 4 there is shown a vessel 20 intended to contain molten metal or a molten alloy. The metal level in the vessel is indicated by reference numeral 21. The vessel 20 comprises an outer wall 22 made from steel and an inner refractory lining 23. In the refractory lining there are two electric heating

elements 24, 25. The heating element 24 is arranged in the bottom of the vessel 20 in such a way that heat is conducted from the top of the block 1 in the heating element 24 to the molten metal contained in the vessel 20. The other surface of the block 1 of the electric heating element 24 is insulated in the refractory lining 23. The heating element 25 is arranged in one of the sidewalls of the vessel 20 and has an opening 26 extending through the block of temperature resistant, heat conducting material. The opening 26 serves as a nozzle for controlled tapping of metal from the vessel 20. The heating element 25 is, apart from the opening 26, insulated in the refractory lining 23. The electric heating element thus transfers a major part of its heat energy to the metal tapped through the opening 26. In this way the temperature of the metal tapped from the vessel can be kept at a constant and controlled temperature thus avoiding problems with solidification of metal in the tapping hole.

CLAIMS

1. An electric heating element comprising one or more electric resistance elements (3), the heating element having means for the supply of electric current (6, 7, 8) to the one or more electric resistance elements (3), characterized in that the one or more electric resistance elements are arranged in one or more respective closed cavities (2) in a block (1) consisting of a high temperature resistant, heat conducting material.

2. An electric heating element according to claim 1, characterized in that the electric resistance elements (3) are in the form of solid bars.

3. An electric heating element according to claim 1, characterized in that the electric resistance elements (3) are in the form of tubes or coils.

4. An electric heating element according to any of claims 1 to 3, characterized in that electric resistance elements (3) are made from graphite.

5. An electric heating element according to any of claims 1 to 3, characterized in that the block (1) of temperature resistant, heat conducting material is made from graphite.

6. An electric heating element according to any preceeding claim, characterized in that gas tight, electric insulating seals (5) are arranged between the electric resistant elements (3) and the outlet openings of the cavities (2) in the block (1).

7. An electric heating element according to any of claims 1 to 5, characterized by means for supplying inert gas to the cavities (2).

8. An electric heating element according to any preceeding claim, characterized in that the block of temperature resistant material

has an opening extending through the block, which opening wholly or partly serves as a tapping hole or tapping nozzle for molten metal.

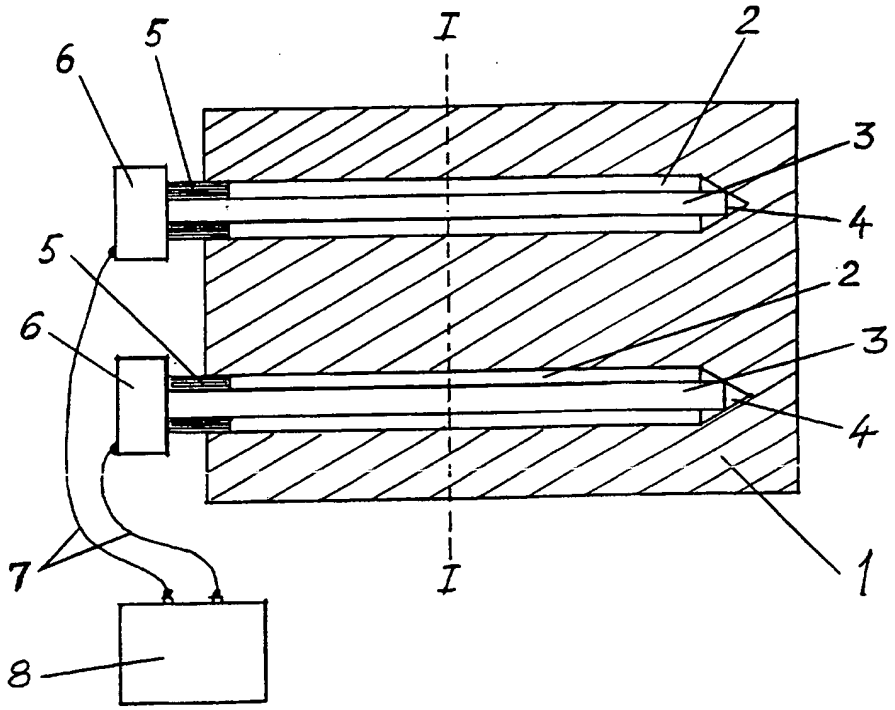

FIGURE 1

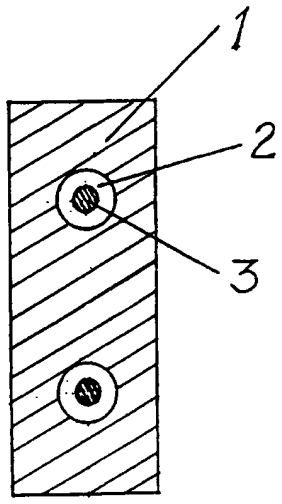

FIGURE 2

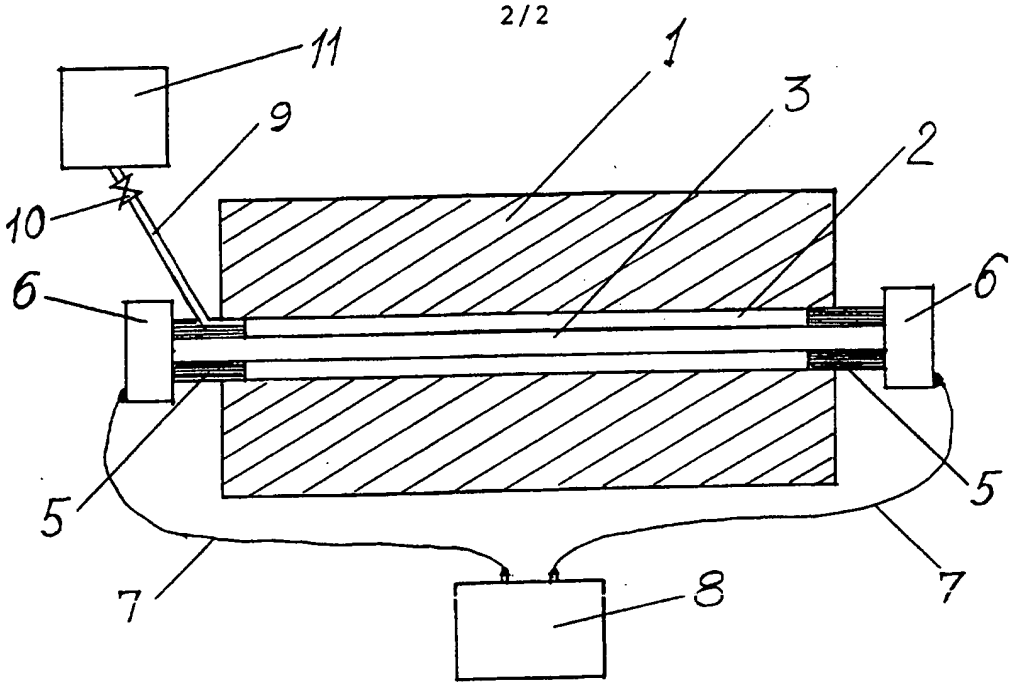

FIGURE 3

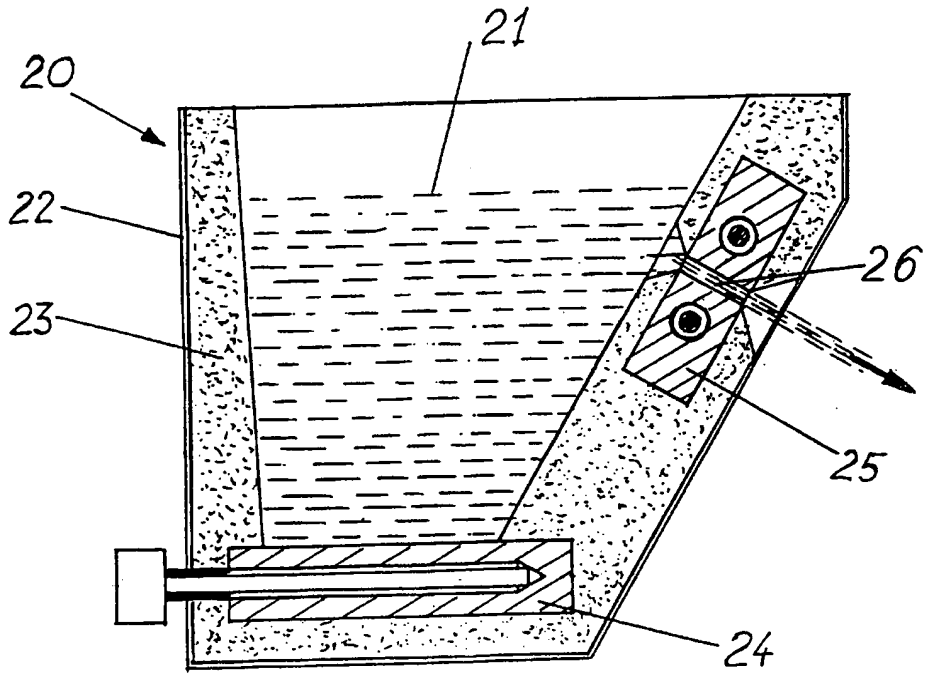

FIGURE 4